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(54) **TRAIN WIRELESS SYSTEM AND TRAIN LENGTH CALCULATION METHOD**

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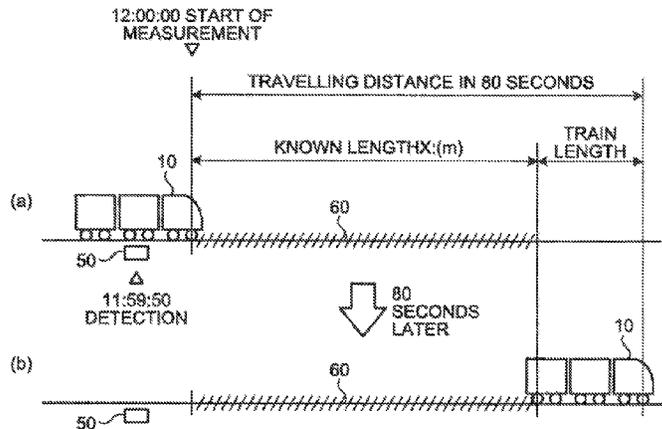(74) *Attorney, Agent, or Firm* — Buchanan Ingersoll & Rooney PC

(57)   **ABSTRACT**
A train wireless system includes a train detecting apparatus on the ground and a controller on a train. The detecting apparatus includes a detector and a calculator. The detector detects that the train is on rails in a block. The calculator measures an on-rail time during which the detector detects the train in the block, and calculates an on-rail detecting time during which the train has been on the rails in the block. The controller includes a distance measurer, a time measurer, a recorder, and a train-length calculator. The distance measurer measures a travelling distance of the train from a beginning of the block, the time measurer measures an

(Continued)

elapsed time since the distance measurer starts the measurement, the recorder records the elapsed time and the travelling distance, and the train-length calculator searches the recorder based on the detecting time, and calculates the train length using a selected travelling distance.

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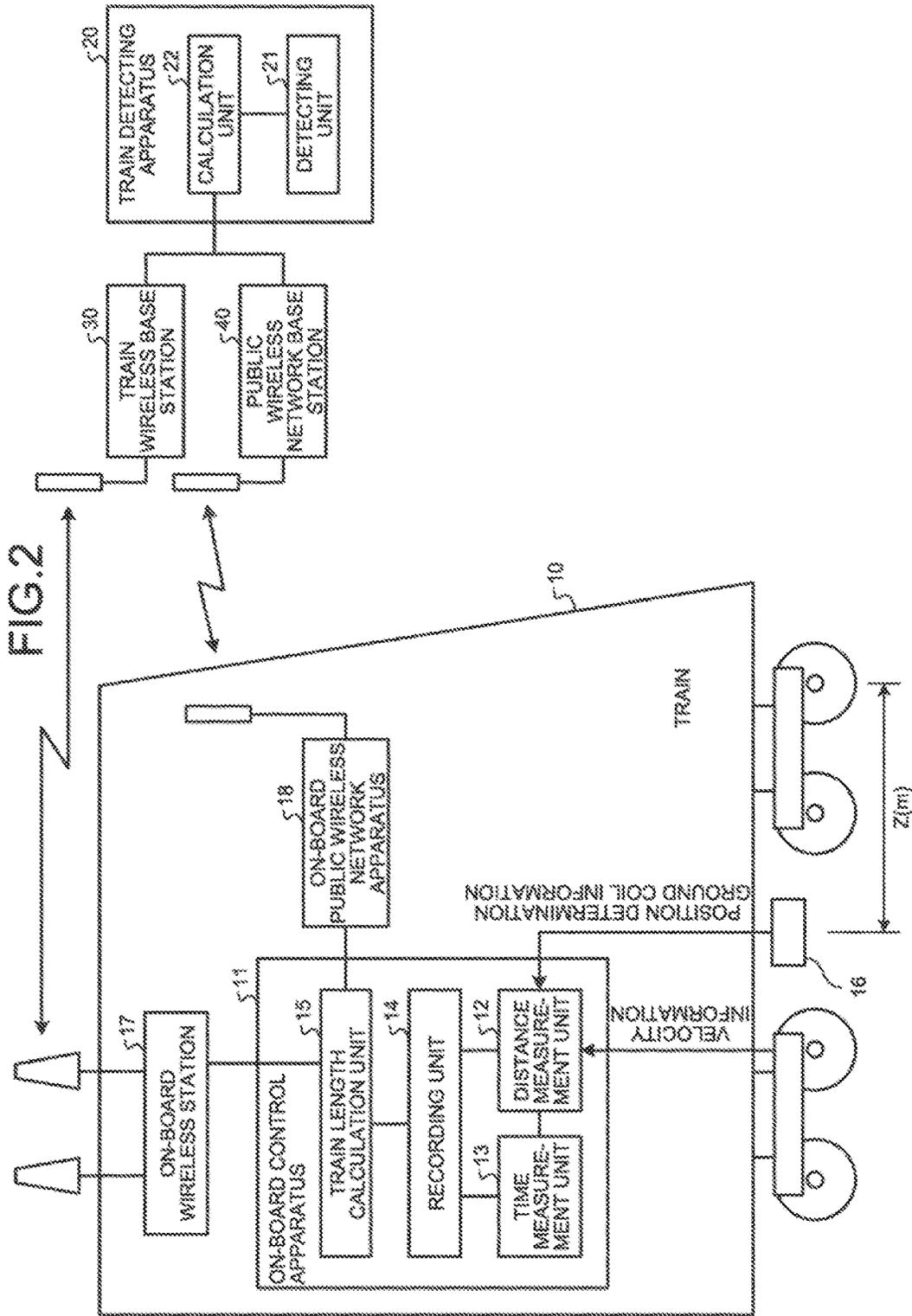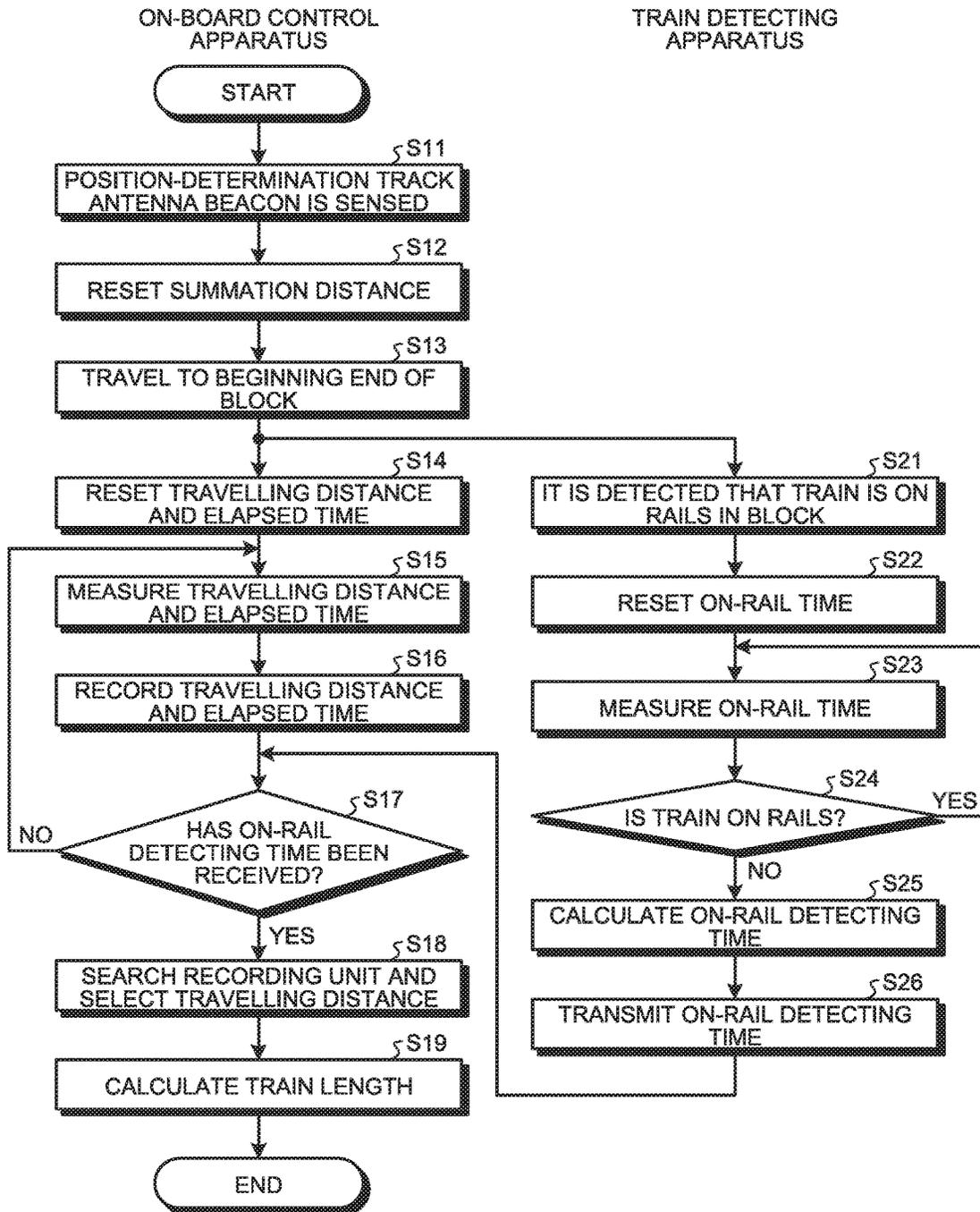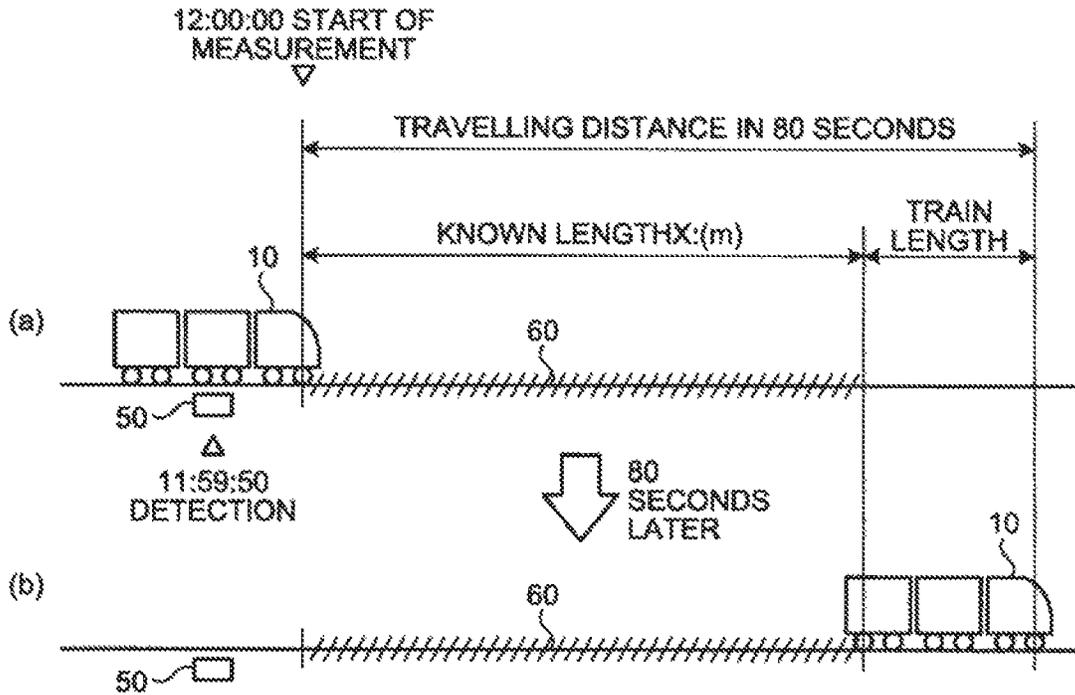
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FIG.1

TRAIN DETECTING APPARATUS

20

TRAIN WIRELESS BASE STATION

30

PUBLIC WIRELESS NET-WORK BASE STATION

40

10

60

BLOCK NUMBER 0801

X(m)

Y(m)

50

FIG.2

FIG.3

ON-BOARD CONTROL
APPARATUS

TRAIN DETECTING
APPARATUS

START

POSITION-DETERMINATION TRACK
ANTENNA BEACON IS SENSED — S11

RESET SUMMATION DISTANCE — S12

TRAVEL TO BEGINNING END OF
BLOCK — S13

RESET TRAVELLING DISTANCE
AND ELAPSED TIME — S14

MEASURE TRAVELLING DISTANCE
AND ELAPSED TIME — S15

RECORD TRAVELLING DISTANCE
AND ELAPSED TIME — S16

HAS ON-RAIL
DETECTING TIME BEEN
RECEIVED? — S17   NO

YES

SEARCH RECORDING UNIT AND
SELECT TRAVELLING DISTANCE — S18

CALCULATE TRAIN LENGTH — S19

END

IT IS DETECTED THAT TRAIN IS ON
RAILS IN BLOCK — S21

RESET ON-RAIL TIME — S22

MEASURE ON-RAIL TIME — S23

IS TRAIN ON RAILS? — S24   YES

NO

CALCULATE ON-RAIL DETECTING
TIME — S25

TRANSMIT ON-RAIL DETECTING
TIME — S26

FIG.4

12:00:00 START OF
MEASUREMENT
▽

TRAVELLING DISTANCE IN 80 SECONDS

KNOWN LENGTHX:(m)

TRAIN
LENGTH

(a)

10

50

60

△
11:59:50
DETECTION

⬇ 80
SECONDS
LATER

(b)

60

10

50

FIG.5

ELAPSED TIME	TRAVELLING DISTANCE	
00:00	0m	◀— RESET
00:01	0.5m	
00:02	2m	
00:03	3m	
00:04	3m	
.	.	
.	.	
.	.	
01:19	79m	
01:20	80m	◀— SELECT
01:21	81m	
01:22	82m	
01:23	83m	

80 SECONDS LATER

FIG.6

| PROCESSOR | MEMORY | INPUT UNIT | OUTPUT UNIT |
| 91 | 92 | 93 | 94 |

95
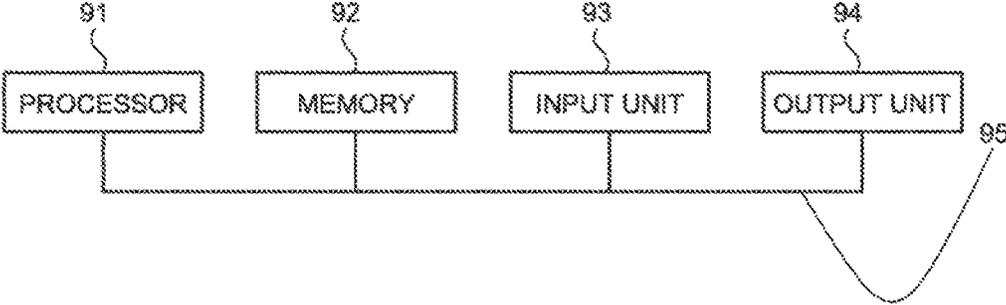
TRAIN WIRELESS SYSTEM AND TRAIN LENGTH CALCULATION METHOD

FIELD

The present invention relates to a train wireless system which performs wireless communication between a train side and a ground side, and a train length calculation method.

BACKGROUND

A conventional train wireless system, which performs traffic control on the basis of an interval between a train and another train preceding or following the train, needs to grasp the lengths and positions of the respective trains. The train wireless system can set a train length to a fixed value when the train has the fixed number of vehicle. However, the train wireless system encounters a problem in setting a length of a train such as a freight train whose number of vehicles of the train varies. When a train driver or a command person manually sets a train length on the basis of the number of vehicles, the mistake in inputting the train length may cause an accident such as collision of trains. With respect to the above problem, Patent Literature 1 below discloses technique for calculating a length of a travelling train by multiplying the velocity of the train by a travelling time during which the train travels.

CITATION LIST

Patent Literature

Patent Literature 1: Japanese Patent Application Laid-Open No. H04-201673

SUMMARY

Technical Problem

However, the conventional technology described above fails to accurately calculate the train length due to the velocity being zero and the travelling time being infinite when the train stops in accordance with a stop signal or the like. In addition to such a problem, a problem with this conventional technique is that facilities on the ground side need costly axle counters with a velocity detecting function.

The present invention has been made in view of the above, and an object of the present invention is to obtain a train wireless system capable of calculating a train length by using a simple configuration.

Solution to Problem

To solve the problem and achieve the object, the present invention provides a train wireless system comprising a train detecting apparatus installed on a ground and an on-board control apparatus mounted on a train, wherein the train detecting apparatus comprises: a detecting unit to detect that the train is on rails in a block that is a section having a track circuit; and a calculation unit to perform control to measure an on-rail time during which the detecting unit detects the train in the block, calculate and transmit, to the train, an on-rail detecting time during which the train has been on the rails in the block, and the on-board control apparatus comprises: a distance measurement unit to measure a travelling distance of the train from a beginning end of the block; a

time measurement unit to measure an elapsed time since the distance measurement unit starts the measurement; a recording unit to record the elapsed time and the travel distance in association with each other; and a train-length calculation unit to search the recording unit on a basis of the on-rail detecting time acquired from the train detecting apparatus, and calculate a train length by using a selected travelling distance.

Advantageous Effects of Invention

The present invention achieves an effect that the train length can be calculated using the simple configuration.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a diagram illustrating a configuration example of a train wireless system.

FIG. 2 is a block diagram illustrating configuration examples of a leading vehicle of a train and a train detecting apparatus.

FIG. 3 is a flowchart illustrating a train length calculation operation performed by an on-board control apparatus and the train detecting apparatus.

FIG. 4 is a diagram illustrating a state in which the train is at a beginning end of a block and a state in which the train is at a terminal end of the block.

FIG. 5 is a chart illustrating one example of elapsed times and travelling distances recorded in a recording unit.

FIG. 6 is a diagram illustrating a hardware configuration of the on-board control apparatus.

DESCRIPTION OF EMBODIMENTS

Hereinbelow, a train wireless system and a train length calculation method according to an embodiment of the present invention will be described in detail with reference to the drawings. The invention is not limited to the embodiment.

Embodiment

FIG. 1 is a diagram illustrating a configuration example of a train wireless system according to an embodiment of the present invention. FIG. 2 is a block diagram illustrating configuration examples of a leading vehicle of a train 10 and a train detecting apparatus 20. The train 10 is assumed to travel from a left side to a right side in FIG. 1.

The train wireless system includes an on-board control apparatus 11 and the train detecting apparatus 20. The on-board control apparatus 11 is mounted on the train 10. The train detecting apparatus 20 is installed on the ground, and detects that the train 10 is on rails in a block 60 of a block number 0801. The block 60 is a section having a track circuit. The train detecting apparatus 20 can communicate with the on-board control apparatus 11 through communication using a licensed frequency band in the train wireless system via a train wireless base station 30, or can communicate with the on-board control apparatus 11 through communication using a public wireless network via a public wireless network base station 40.

In FIGS. 1 and 2, a distance Z (m) between a pickup coil 16 and an axle with which the train 10 first short-circuits the track circuit of the block 60 is a known value. A distance Y (m) between a position-determination track antenna beacon 50 and a beginning end of the block 60 is a known value. The pickup coil 16 determines a position of the train 10 upon

moving past the position-determination track antenna beacon **50**. After the train **10** travels a distance of Y–Z (m) since the train **10** detects the position-determination track antenna beacon **50**, the on-board control apparatus **11** starts measuring a travelling distance and an elapsed time. The travelling distance is a distance by which the train **10** travels in the block **60** since the train **10** enters the rails in the block **60**. The elapsed time is a period of time during which the travelling distance is measured.

Since the train **10** travels from the left side to the right side in FIG. **1**, the left side and the right side of the block **60** are beginning and terminal ends thereof, respectively. The beginning end of the block **60** is the same as that of the track circuit, and the terminal end of the block **60** is the same as that of the track circuit. When the train detecting apparatus **20** detects that the train **10** is on the rails in the block **60**, it is meant that the apparatus **20** detects that the train **10** short-circuits the track circuit. In the following description, it is noted that the train **10** short-circuiting the track circuit is construed to be on the rails in the block **60**.

Subsequently, the configuration of the train detecting apparatus **20** will be described. The train detecting apparatus **20** includes a detecting unit **21** and a calculation unit **22**. The detecting unit **21** detects that the train **10** is on the rails in the block **60** as the track circuit is short-circuited. The calculation unit **22** performs control to: measure an on-rail time during which the detecting unit **21** detects that the train **10** is on the rail in the block **60**; calculate an on-rail detecting time during which the train **10** has been on the rail in the block **60**, i.e., a period of time during which the train **10** has been short-circuiting the track circuit, after moving past the terminal end of the block **60**; and transmit information on the on-rail detecting time to the train **10** via the train wireless base station **30** or the public wireless network base station **40**.

Next, the configuration of the train **10** will be described. The train **10** includes the on-board control apparatus **11**, the pickup coil **16**, an on-board wireless station **17**, and an on-board public wireless network apparatus **18**. The on-board control apparatus **11** calculates a train length of the train **10**. The pickup coil **16** detects the position-determination track antenna beacon **50** installed on the ground. The on-board wireless station **17** transmits and receives a signal to and from the train detecting apparatus **20** through communication using a licensed frequency band. The on-board public wireless network apparatus **18** transmits and receives a signal to and from the train detecting apparatus **20** through communication using a public wireless network. After the train length is obtained by the calculation, the train **10** can be controlled can be performed by the train wireless system. Since such control is performed similarly to ordinary control, a description thereof will be omitted except for the configuration regarding the calculation of the train length.

The on-board control apparatus **11** includes a distance measurement unit **12**, a time measurement unit **13**, a recording unit **14**, and a train-length calculation unit **15**. The distance measurement unit **12** measures a travelling distance by which the train **10** travels from the beginning end of the block **60**. The time measurement unit **13** measures an elapsed time since the distance measurement unit **12** starts measuring the travelling distance of the train **10**. The recording unit **14** records the elapsed time measured by the time measurement unit **13** and the travelling distance measured by the distance measurement unit **12** in association with each other. The train-length calculation unit **15** searches the recording unit **14** on the basis of the on-rail detecting time

acquired from the train detecting apparatus **20**, and obtains the train length of the train **10** by calculation using a selected travelling distance.

Subsequently, a method for calculating the train length of the train **10** in the train wireless system will be described. FIG. **3** is a flowchart illustrating a train length calculation operation performed by the on-board control apparatus **11** and the train detecting apparatus **20**.

First, in the on-board control apparatus **11** of the train **10**, when the pickup coil **16** detects the position-determination track antenna beacon **50** (Step S**11**), the distance measurement unit **12** resets a summation distance obtained by adding up movement distances of the train **10** on the basis of position-determination track-antenna-beacon information from the pickup coil **16** (Step S**12**).

The distance measurement unit **12** measures the summation distance of the train **10** by "a wheel diameter of the train **10**×π×(the number of pulses/the number of teeth in a wheel of the train **10**)" on the basis of pulses of velocity information output from a velocity sensor (not illustrated). The distance measurement unit **12** measures a running distance similarly by the formula described above. When the train **10** travels to the beginning end of the block **60** (Step S**13**), more specifically, when the summation distance of the train **10** obtained since the summation distance measured so far is reset reaches a beacon-to-block distance of Y–Z (m) obtained by subtracting a known distance Z (m), which is a distance from the pickup coil **16** to the axle of the train **10** which first short-circuits the track circuit after entering the block **60**, from a known distance Y (m) which is a distance from the position-determination track antenna beacon **50** to the beginning end of the block **60**, the distance measurement unit **12** resets a travelling distance indicating a distance by which the train **10** has traveled so far in the block **60** (Step S**14**).

When the train **10** travels the distance Y–Z (m) and the travelling distance is reset after the resetting of the summation distance, the distance measurement unit **12** notifies the time measurement unit **13** so. When the time measurement unit **13** receives the notification from the distance measurement unit **12**, in other words, when the train **10** travels the distance Y–Z (m) since the summation distance is reset, the time measurement unit **13** resets an elapsed time which is a period of time during which the distance measurement unit **12** measures the travelling distance (Step S**14**).

When resetting the travelling distance, the distance measurement unit **12** measures a travelling distance of the train **10** in the block **60** (Step S**15**). When resetting the elapsed time, the time measurement unit **13** measures an elapsed time (Step S**15**). The distance measurement unit **12** measures the travelling distance in a fixed cycle according to timing of pulses output from the velocity sensor, and records the measured travel distance in the recording unit **14** (Step S**16**). The time measurement unit **13** records the elapsed time in the recording unit **14** at timing when the distance measurement unit **12** measures and records the travelling distance in the recording unit **14** (Step S**16**).

The distance measurement unit **12** may record the travelling distance in the recording unit **14** and the time measurement unit **13** may record the elapsed time in the recording unit **14** in synchronization with each other. Alternatively, the distance measurement unit **12** may acquire information on the elapsed time from the time measurement unit **13**, and then record the travelling distance and the elapsed time in the recording unit **14**. In the recording unit **14**, the elapsed time measured by the time measurement unit **13** and the

travelling distance measured by the distance measurement unit **12** are recorded in association with each other.

When the train **10** travels to the beginning end of the block **60** (Step S13), on the other hand, the detecting unit **21** of the train detecting apparatus **20** detects that the train **10** is on the rails in the block **60** as the track circuit is short-circuited (Step S21).

When the detecting unit **21** detects that the train **10** is on the rails, the calculation unit **22** of the train detecting apparatus **20** resets the on-rail time which indicates a period of time during which the train **10** is on the rails in the block **60** (Step S22), and measures the on-rail time during which the detecting unit **21** detects that the train **10** is on the rails (Step S23). When the train **10** is on the rails in the block **60** (Step S24: Yes), the calculation unit **22** measures the on-rail time during which the detecting unit **21** detects that the train **10** is on the rails in the block **60** as the track circuit is short-circuited (Step S23).

When the train **10** is not on the rails in the block **60** (Step S24: No), in other words, when the train **10** moves past the terminal end of the block **60** and the detecting unit **21** can no longer detect that the train **10** is on the rails in the block **60**, the calculation unit **22** calculates an on-rail detecting time during which the train **10** has been on the rails in the block **60**, the on-rail detecting time being a period of time from the entry of the train **10** into the block **60** to the exiting of the train **10** from the block **60** (Step S25). The calculation unit **22** takes, as the on-rail detecting time, a period of time from when the detecting unit **21** detects that the train **10** is on the rails in the block **60** to when the detecting unit **21** can no longer sense that the train **10** is on the rails. However, when a delay time, which is a timer delay (TD), is set in the detecting unit **21** in order to allow the detecting unit **21** a margin in detecting the train **10**, the calculation unit **22** takes, as the on-rail detecting time, a value obtained by subtracting the delay time from the time during which the detecting unit **21** has been detecting that the train **10** is on the rails in the block.

Then, the calculation unit **22** transmits information on the calculated on-rail detecting time to the train **10** via the train wireless base station **30** or the public wireless network base station **40** (Step S26). The calculation unit **22** may use either one or both of the train wireless base station **30** and the public wireless network base station **40**. The calculation unit **22** may use the one base station usually, and when failing to communicate with the train via the one base station, the calculation unit **22** may use the other base station.

Either one or both of the on-board wireless station **17** and the on-board public wireless network apparatus **18** of train **10** can receive the information on the on-rail detecting time transmitted from the train detecting apparatus **20**. Until the train **10** receives the information on the on-rail detecting time (Step S17: No), the distance measurement unit **12** measures the travelling distance (Step S15) and records the measured travelling distance in the recording unit **14** (Step S16), and the time measurement unit **13** measures the elapsed time (Step S15) and records the measured elapsed time in the recording unit **14** (Step S16).

In the train **10**, when the train **10** receives the information on the on-rail detecting time (Step S17: Yes), the train-length calculation unit **15** searches the recording unit **14** on the basis of the on-rail detecting time acquired from the train detecting apparatus **20** and selects a travelling distance used for calculation of a train length (Step S18). More specifically, the elapsed times recorded in the recording unit **14** include elapsed times that meet the condition "the elapsed times≧the on-rail detecting time". The train-length calcula-

tion unit **15** selects the shortest one of the travelling distances recorded with the elapsed times which meet the condition.

Then, the train-length calculation unit **15** uses the selected travel distance to calculate a train length by "the selected travelling distance−the known length X (m) of the block **60**+an extra length" (Step S19). The length X (m) of the block **60** is a known value. The extra length is a length determined in consideration of a portion of the train **10** which cannot be detected in the block **60**.

In FIG. **3**, Steps S11 to S15 can be taken as a step of measuring the travelling distance and the elapsed time. Step S16 can be taken as a step of recording the elapsed time and the travel distance. Steps S21 to S26 can be taken as a step of calculating the on-rail detecting time during which the train **10** has been on the rails in the block **60**. Steps S17 to S19 can be taken as a step of calculating the train length.

The train-length calculation method will be described using a specific example. FIG. **4** is a diagram illustrating a state in which the train **10** is at the beginning end of the block **60** and a state in which the train **10** is at the terminal end of the block **60**. FIG. **5** is a chart illustrating one of example of the elapsed times and the travelling distances recorded in the recording unit **14**.

FIG. **4**(*a*) illustrates a state in which the train **10** detects the position-determination track antenna beacon **50** at "11: 59:50," and enters the block **60** at "12:00:00," when the train **10** starts measuring a travelling distance and an elapsed time. FIG. **4**(*b*) illustrates a state in which the train **10** has moved past the block **60** after a lapse of 80 seconds following the entry into the block **60**. The train **10**, which enters the block **60**, should travel a distance that is the sum of the length of the block **60** and the length of the train **10** in order to move past the block **60**. In other words, if the travelling distance by which the train **10** has traveled in 80 seconds is known, a train length of the train **10** can be obtained by subtracting the known length X (m) of the block **60** from the travelling distance.

As illustrated in FIG. **4**(*a*), by the time the train **10** enters the block **60** and the train detecting apparatus **20** can detect that the train **10** is on the rails in the block **60**, the train **10** has already entered the block **60** at its portion having a distance from the front end of the train **10** to the train's axle that first enters the block **60**, in other words, first short-circuits the track circuit. As illustrated in FIG. **4**(*b*), at a point of time when the train **10** exits the block **60** and the train detecting apparatus **20** can no longer detect that the train **10** is on the rails in the block **60**, in other words, when the track circuit is no longer short-circuited, the train **10** is still in the block **60** at its portion having a distance from the rear end of the train **10** to the train's axle that has last short-circuited the track circuit. Therefore, the calculation of the train length should take into consideration an extra length that is the sum of the distance from the front end of the train **10** to the train's first axle that short-circuits the track circuit and the distance from the rear end of the train **10** to the train's last axle that has short-circuited the track circuit.

When the train-length calculation unit **15** receives from the train detecting apparatus **20** information indicating that an on-rail detecting time during which the train **10** has been on the rails in the block **60** is 80 seconds, the train-length calculation unit **15** can search the recording unit **14**, and select the travel distance of "80 m" at the elapsed time of "12:01:20" which is 80 seconds after the elapsed time of "12:00:00" at which the measurement of the travelling

distance has started. The train-length calculation unit **15** can obtain the train length by the above formula using the selected "80 m."

With regard to the on-rail detecting time received from the train detecting apparatus **20**, a delay time may be set in the train detecting apparatus **20**, in which case the train-length calculation unit **15** receives the on-rail detecting time from the train detecting apparatus **20** at a delayed timing after the train **10** actually moves past the block **60**. Even in this case, when the train length calculation unit **15** receives the on-rail detecting time from the train detecting apparatus **20**, the train-length calculation unit **15** can search the recording unit **14** retroactively from the current time and select a travelling distance, because the recording unit **14** records a travelling distance for each elapsed time.

FIG. **5** illustrates an example in which an elapsed time and a travel distance are recorded every one second. The interval between the elapsed times is, as described above, an interval of pulses output from the velocity sensor (not illustrated). For the pulse interval of 0.2 seconds, thus, the measurement of the travelling distance by the distance measurement unit **12**, the measurement of the elapsed time by the time measurement unit **13**, and the recording of the travelling distance and the elapsed time in the recording unit **14** are done every 0.2 seconds. In FIG. **5**, among the elapsed times recorded in the recording unit **14** is an elapsed time corresponding to the on-rail detecting time received from the train detecting apparatus **20**. However, no elapsed time can correspond to the on-rail detecting time when a unit of the on-rail detecting time is one second or smaller. In that case, among the elapsed times recorded in the recording unit **14**, the elapsed times which the train-length calculation unit **15** takes as candidates in selecting a travelling distance should meet the condition "the elapsed times≥the on-rail detecting time", as described above.

Although, in FIG. **5**, the time measurement unit **13** measures the elapsed times to display the same using time points, this is only an example. The elapsed times may be displayed like zero second, one second, and two seconds. With a function such as a stopwatch, the calculation unit **22** of the train detecting apparatus **20** will suffice to measure the time during which the detecting unit **21** detects the train **10** in the block **60** because the calculation unit **22** is only required to be capable of measuring a period during which the train **10** is on the rails in the block **60**. It is not necessary for the calculation unit **22** to have a timepiece function, and even when having the timepiece function, the calculation unit **22** need not synchronize with the train **10**.

In the train **10**, the train-length calculation unit **15** of the on-board control apparatus **11** transmits information on the calculated train length to a ground control apparatus of the train wireless system via the on-board wireless station **17** or the on-board public wireless network apparatus **18**. It is also possible to incorporate the train detecting apparatus **20** in the ground control apparatus. It is also possible for the train-length calculation unit **15** to transmit the train length to the train detecting apparatus **20** via the on-board wireless station **17** or the on-board public wireless network apparatus **18**, and transmit information thereon to the ground control apparatus via a ground-side network. Consequently, train control for the train **10** can be achieved in the train wireless system.

A description will be given for a hardware configuration which provides each element in the block diagram of the on-board control apparatus **11** illustrated in FIG. **2**. FIG. **6** is a diagram illustrating the hardware configuration of the on-board control apparatus **11**. The distance measurement

unit **12** and the time measurement unit **13** are implemented by an input unit **93** and a processor **91** which executes a program stored in a memory **92**. The recording unit **14** is implemented by the memory **92**. The train-length calculation unit **15** is implemented by the input unit **93**, an output unit **94**, and the processor **91** which executes a program stored in the memory **92**. The processor **91**, the memory **92**, the input unit **93**, and the output unit **94** are connected by a system bus **95**. In the on-board control apparatus **11**, a plurality of processors **91** and a plurality of memories **92** may cooperate to execute a function of each element illustrated in the block diagram in FIG. **2**. While the on-board control apparatus **11** can be implemented by the hardware configuration illustrated in FIG. **6**, the apparatus **11** can be implemented by either of software and hardware. The train detecting apparatus **20** can be implemented by the hardware configuration illustrated in FIG. **6** as well.

As described above, according to the present embodiment, the train wireless system includes the train detecting apparatus **20** installed on the ground and the on-board control apparatus **11** mounted on the train **10**. The detecting unit **21** of the train detecting apparatus **20** detects that the train **10** is on the rails in the block **60** having the track circuit and the calculation unit **22** calculates and transmits the on-rail detecting time to the train **10**. In the on-board control apparatus **11** of the train **10**, the distance measurement unit **12** measures the travelling distance of the train **10** from the beginning end of the block **60** and records the travelling distance in the recording unit **14**, the time measurement unit **13** measures the elapsed time since the distance measurement unit **12** starts measuring the travelling distance and records the elapsed time in the recording unit **14**, and the train length calculation unit **15** searches the recording unit **14** on the basis of the on-rail detecting time acquired from the train detecting apparatus **20**, and calculates the train length by using the selected travel distance. This eliminates the necessity of installing the costly axle counter with the velocity-detecting function. The train wireless system uses the existing block **60** and the non-powered position-determination track antenna beacon **50** for entering the train wireless system to enable the on-board control apparatus **11** to calculate the train length by using the known length and the travelling distance selected on the basis of the on-rail detecting time from the record of travelling distances for respective elapsed times from the start of the measurement of the travelling distance. That is, the train length can be calculated by the simple configuration.

The configuration described in the embodiment above indicates one example of the content of the present invention and can be combined with other known technology, and a part thereof can be omitted or modified without departing from the gist of the present invention.

REFERENCE SIGNS LIST

10 train, **11** on-board control apparatus, **12** distance measurement unit, **13** time measurement unit, **14** recording unit, **15** train-length calculation unit, **16** pickup coil, **17** on-board wireless station, **18** on-board public wireless network apparatus, **20** train detecting apparatus, **21** detecting unit, **22** calculation unit, **30** train wireless base station, **40** public wireless network base station, **50** position-determination track antenna beacon, **60** block, **91** processor, **92** memory, **93** input unit, **94** output unit, **95** system bus.

The invention claimed is:

1. A train wireless system comprising:
a train detecting apparatus installed on a ground; and
an on-board control apparatus mounted on a train, wherein:
the train detecting apparatus includes at least one processor that:
    detects that the train is on rails in a block that is a section of the rails having a track circuit; and
    controls measurement of an on-rail time during which the train is detected in the block, and calculation and transmission, to the train, of an on-rail detecting time during which the train has been on the rails in the block, and
the on-board control apparatus includes at least another processor that:
    measures a travelling distance of the train from a beginning end of the block, wherein the travelling distance is measured when, after a position-determination track antenna beacon is detected by a pickup coil, the train travels a distance obtained by subtracting a distance from the pickup coil to an axle of the train from a distance from the position-determination track antenna beacon to the beginning end of the block, the axle short-circuiting the track circuit first in the train;
    measures an elapsed time since the measurement of the traveling distance is started;
    records the elapsed time and the traveling distance in a memory in association with each other; and
    searches recorded elapsed times on a basis of the on-rail detecting time acquired from the train detecting apparatus, and calculates a train length using an accordingly selected travelling distance.

2. The train wireless system according to claim 1, wherein recorded elapsed times include elapsed times that meet a condition that the elapsed times are equal to or greater than the on-rail detecting time, and
the on-board control apparatus selects a shortest one of travelling distances recorded with the elapsed times that meet the condition.

3. The train wireless system according to claim 1, wherein the on-board control apparatus takes, as the train length, a value obtained by subtracting a known length of the block from the selected travel distance, and adding an extra length thereto.

4. The train wireless system according to claim 3, wherein the extra length is a sum of a distance from a front end of the train to an axle of the train that short-circuits the track circuit first in the train, and a distance from a rear end of the train to an axle of the train that has short-circuited the track circuit last in the train.

5. The train wireless system according to claim 1, wherein when a delay time is set in determination of whether the train is on the rails in the block, the train detecting apparatus takes, as the on-rail detecting time, a value obtained by subtracting the delay time from the on-rail time.

6. The train wireless system according to claim 1, wherein the train detecting apparatus controls the transmission of the on-rail detecting time via a train wireless base station that performs communication using a licensed frequency band in a train wireless system, and
in the train, a licensed-frequency-band on-board wireless station receives the on-rail detecting time through com-

munication using the licensed frequency band, and outputs the on-rail detecting time to the on-board control apparatus.

7. The train wireless system according to claim 1, wherein the train detecting apparatus controls the transmission of the on-rail detecting time via a public wireless network base station that performs communication using a public wireless network, and
in the train, an on-board public wireless network apparatus receives the on-rail detecting time through communication using the public wireless network, and outputs the on-rail detecting time to the on-board control apparatus.

8. A train-length calculation method in a train wireless system comprising a train detecting apparatus installed on a ground and an on-board control apparatus mounted on a train, the method comprising:
    measuring, via at least an input unit and at least one processor of the on-board control apparatus, a travelling distance of the train from a beginning end of a block that is a section of the rails having a track circuit, and measuring an elapsed time since the measurement of the traveling distance is started, wherein measuring the travelling distance and the elapsed time comprises measuring the travelling distance and the elapsed time when, after a position-determination track antenna beacon is detected by a pickup coil, the train travels a distance obtained by subtracting a distance from the pickup coil to an axle of the train from a distance from the position-determination track antenna beacon to the beginning end of the block, the axle short-circuiting the track circuit first in the train;
    recording the elapsed time and the travel distance in a memory in association with each other;
    measuring, via the at least one processor of the on-board control apparatus, an on-rail time during which the train is on rails in the block, and calculating an on-rail detecting time during which the train has been on the rails in the block; and
    searching, via the at least one processor of the on-board control apparatus, the memory on a basis of the on-rail detecting time, and calculating a train length using an accordingly selected travelling distance.

9. The train length calculation method according to claim 8, wherein
elapsed times recorded in the memory include elapsed times that meet a condition that the elapsed times are equal to or greater than the on-rail detecting time, and
searching the memory and calculating the train length comprises selecting a shortest one of travelling distances recorded with the elapsed times that meet the condition.

10. The train length calculation method according to claim 8, wherein
searching the memory and calculating the train length comprises taking, as the train length, a value obtained by subtracting a known length of the block from the selected travel distance, and adding an extra length thereto.

11. The train length calculation method according to claim 10, wherein
the extra length is a sum of a distance from a front end of the train to an axle of the train that short-circuits the track circuit first in the train, and a distance from a rear end of the train to an axle of the train that has short-circuited the track circuit last in the train.

12. The train length calculation method according to claim **8**, wherein

when a delay time is set in determination of whether the train is on the rails in the block, measuring the on-rail time and calculating the on-rail detecting time comprises taking, as the on-rail detecting time, a value obtained by subtracting the delay time from the on-rail time.

13. The train length calculation method according to claim **8**, comprising:

transmitting the on-rail detecting time via a train wireless base station that performs communication using a licensed frequency band in a train wireless system; and

receiving the on-rail detecting time through communication using the licensed frequency band, and outputting the on-rail detecting time to the on-board control apparatus.

14. The train length calculation method according to claim **8**, comprising:

transmitting the on-rail detecting time via a public wireless network base station that performs communication using a public wireless network; and

receiving the on-rail detecting time through communication using the public wireless network, and outputting the on-rail detecting time to the on-board control apparatus.

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